

RACKET FORMATION IN THE TAIL-FEATHERS OF THE MOTMOTS.

PART I.

One of the most interesting and puzzling of the myriad problems in ornithology is the apparent voluntary mutilation of plumage by birds. This phenomenon is a rare one, being confined, as far as I can ascertain, to the Momoti, a sub-order of that ill-defined group, Coraciiformes. Some twenty-four forms of Motmots are recognized, ranging from Mexico to Brazil.

It is not my intention to review in detail the well-known facts of the denudation of the tail feathers in these birds. For some time I have had under observation a living individual of *Momotus lessoni* Less. of unknown sex, and as my experiments on this bird must for the present be suspended, I have thought it worth while to record what results I have obtained.

The problem is as follows:—the central pair of tail feathers of this bird are about three inches longer than the next shorter pair, and after growth, the bird apparently plucks the web from each side of the shaft of these rectrices, for a distance of about an inch, leaving a terminal racket one and a half inches in length. If we consider this as a habit, it is an instinctive one, as proved by Cherrie* in young birds removed from the nest. These denuded their tails in perfect Motmot fashion without any chance of instruction or of imitation of the parents.

The fact that before the feathers are denuded, the webs at this point are narrower than elsewhere has been urged by Lamarckians as an instance of the inheritance of acquired characters, the argument being that Motmots have denuded their tail feathers for generation after generation, until the imperfection has in some way been transmitted to the germ, and these feathers are now congenitally imperfect. If true, this would prove almost a unique instance of this kind. Other, even more groundless, theories have been advanced, but the fact is we have

*The Auk. Vol. ix, 1892, p. 323.

known absolutely nothing of the actual cause of this phenomenon; either how it arose, why it is so persistent, or what good is accomplished.

PART II.

The Motmot is clad in browns and greens, and is a rather silent, sedentary bird. It would be thoroughly protected on its perch among green foliage were it not for a constant and violent jerking of the closed tail from side to side, through an arc of 45 to 60 degrees. This movement, accentuated by the large isolated rackets, calls instant attention to the bird as one looks in its direction. Its food in nature consists chiefly of insects and berries, although it will occasionally exhibit Shrike-like habits and turn ornithophagus.

The individual under consideration has been in my possession since September 5th, 1908, and in general has been in perfect health, moulting twice, heavily but cleanly, in September of each year. When received, the rackets were broken off, but the bare inch of terminal shaft showed that the tail feathers had been normally stripped of web. In early October, 1908, the Motmot began to preen the webs of its newly-grown rectrices and within a week the denudation was complete.

The upper limit of the stripped area appears always to be at the tips of the second longest pair of tail feathers, so the first thing I wished to discover was whether these other rectrices exercised any guiding function in aiding the bird in this remarkably symmetrical trimming.

On January 14th, 1909, I plucked out the two longest feathers and at the same time cut straight across the second and third shorter pairs of tail feathers. This took off about two and a quarter inches of the second, and one and a half inches of the third pair. These clipped feathers of course remained in the same shortened condition until the succeeding moult, while the plucked out central rectrices began growing at once.

When full grown, they were trimmed by the bird as before and careful measurements of the denuded area compared with that of the previous pair of tail feathers, showed that there was no variation. *Without the guide of the second and third rectrice tips, the trimming was as accurate as ever.*

PART III.

Early in the fall of the present year (1909) the Motmot began to moult very heavily, and became so quiet and moped so

much, with head drawn in and eyes shut, that I was alarmed. An examination showed, however, that the bird was in fair condition and would undoubtedly live through its moult. At this critical time I again plucked the long tail feathers which, by their bedraggled condition, showed the lack of care due to the moult illness. Daily I watched for the new incoming feathers, and daily the blood sheaths grew longer. Finally, when they were about four inches in length, the drying sheath began to crack and fray off, releasing the folded vane within.

When this natural unsheathing had proceeded for several days, a portion of the feather appeared disarranged. When the sheath broke from this part, the fact was made plain that the disordered appearance was due to part of the web coming away with the sheath, and the irregular breaking off of the latter made the separated barbs stand out in all directions before being lost. When the feathers grew out still more, it was seen that above the rackets the regular denuded portion of the shaft was as bare as if the Motmot had stripped it. This was an interesting result and is probably explained by the low vitality of the bird and the severe strain on its plumage-producing resources causing a lessened and insufficient nutrition in the development of these long feathers. The radical result of the physiological loss of the vane is to be interpreted by the existence of an actual weakened condition of the bases of the barbs of the normally trimmed area, which was intensified under the influence of the moulting illness in this captive bird. This increased weakness in the barbs took the form of an actual separation, simulating the dynamic denudation of the bird's beak.

Whether or not this result furnishes a proof of the inheritance of acquired characters is aside from my present thesis. I wish simply to demonstrate that in the Motmot, the condition of these tail feathers is such that transference of the denudation from a physical act on the part of the bird to a purely physiological process is not impossible, although at present abnormal.

How long it would take for this process to occur normally, in the evolution of this phenomenon, is of course impossible to say. That it would in time advance to the condition which I produced artificially is reasonable to suppose.

Compared with the normal physical results of denudation, those physiologically induced are remarkably uniform, as the following measurements in millimeters show:

	Normally Trimmed Rectrices, Removed Jan. 14, 1909.		Physiologically Denuded Rectrices, Removed Oct. 1, 1909.	
	Left.	Right.	Left.	Right.
Outer webs—				
Racket, length	52	51	50	51
Bare shaft, length	19	23	26	26
Inner webs—				
Racket, length	54	55	54	55
Bare shaft, length	21	22	19	22

As will be seen, the differences in the two sets of feathers are so slight as to be negligible. The only distinction is in the neatness—the physiologically denuded areas are clean-cut to the limits, while in the bird-trimmed feathers, stray barbs are left here and there near the ends of the bare area. Such a difference is interesting and to be expected.

Although it has been so stated by a number of recent writers,* I can find no authentic account of the voluntary denudation of its elongated central tail feathers by the Racket-tailed Parrot, *Prioniturus platurus*, an inhabitant of the East Indian island of Celebes. On the contrary the bird seems to have reached, or at least at present exhibits, the stage of physiological denudation—much as in my artificial condition of the Motmot.

Concerning this bird we read as follows:—**

“The specimens in the Dresden Museum prove that the webs are neither rubbed off, nor bitten off as in the case of the Motmots. . . . Two specimens display the growing racket as found underneath the upper tail-coverts; the shaft is already webless even where it is still enclosed in the corneous husk or follicle out of which the young feather has grown and where it could of course be neither rubbed nor bitten. On removing a third younger sprouting racket by the root and taking off the epidermal husk it was found that the web is present on either side of the shaft, but some of the rami appear not to be attached at all but to run, soldered together, parallel to the shaft almost to its roots; other rami have become individually broken off or have fallen off from the shaft, and it was easy to see that, as the feather grew longer, all would have fallen from the shaft. In a growing racket with the shaft 35 mm., cut out of the tail of an adult male bird it was not possible to detect any signs with cer-

*For example, “Through Southern Mexico,” Gadow, p. 483.

**“Birds of Celebes,” Meyer and Wiglesworth, Vol. i, p. 74.





FIG. 44. Tail-feathers of Mexican Motmots, Showing the Beginning and Completion of Racket Formation.



FIG. 45. Tail-feather of Lesson Motmot, Showing Physiological Denudation.

tainty another shaft was found to be bare down to its point of attachment by the side of the oil-gland; near the base alone some corneous matter of uncertain determination, but perhaps feather-material, was adhering to it.

"These investigations tend to prove that no web at all is produced with long-shafted rackets, but rackets of a lower stage of development have imperfect or unattached webs which fall off before the racket is fully exposed."

PART IV.

Now as to the relation in the Motmot, between the permanently feathered and the ontogenetically defeathered areas of the two rectrices. The fact of the narrowing of the webs has already been mentioned. In a specimen of *Momotus mexicanus* Swains, in my collection (No. 819) the narrowing of the vane begins considerably above the area of subsequent denudation. At its narrowest part the constricted area, compared with the width of the normal vane, is as 3 : 4.

Microscopic examination yields certain results of value in connection with my experiments. The full-grown right central rectrice of one of my specimens, *Momotus mexicanus* (No. 819) is untrimmed except for fourteen barbs on the inner web, the absence of these leaving the shaft bare for a distance of 11 millimeters. Now the racket in this species, as shown by several other trimmed specimens, is about an inch and a quarter in length and holding this untrimmed feather up against the light one can perceive at once what will be the ultimate area of denudation. Elsewhere the vane is dense and compact close up to the shaft, but in this area the basal portion of the barbs is bare, allowing the light to pass through, distinctly near the center of ultimate denudation and graduating down to the normal condition of the feather at the limits of the area.

The rectrices of *Momotus lessoni* being larger and coarser in every way, show this condition even more distinctly, especially where a single stray barb has escaped the beak-trimming process. Even in a fully trimmed feather, a certain amount of imperfection of the basal portions of the barbs is visible for some distance at each end, showing that the actual area of weakened feather structure is greater than the area trimmed by the bird. *The result of the bird's preening is apparently controlled by the weakness and ease of fracture of the barbs rather than by proximity of other feathers or of visual estimate of the size of the racket.*

This has been hinted at by Dr. Stejneger* but unfortunately for his illustration, he has used a feather exhibiting an ordinary fault-bar, caused, as we know, by some sudden and local disturbance in nutrition, either of the bird as a whole or of a particular feather follicle. Similar faults may result from so slight a cause as the difference in blood pressure during the sleeping and waking hours. This results in a transverse faulting across the entire vane—affecting the tips of the proximal barbs and the centers or bases of those more distal ones which are in process of development at the period in question.

The weakness of the vane of the Motmot's tail is far more fundamental, in reality an organic inheritance; the faults or degeneration affecting only the bases of the barbs within a definite limited area—and the faulting thus being longitudinal. Of considerable interest is Stejneger's illustration of a specimen in the collection of the United States National Museum, where a slight denudation—symmetrical in the two feathers—exists on a pair of rectrices which have only just escaped from the enveloping sheath. This would seem to indicate that physiological denudation has already begun in nature and that the bird's part is becoming a subordinate one.

Under a magnification of twenty-five diameters, the distinction between the normal and the weakened portions of the vane is seen to consist in the dwarfing or absence of the barbules, and of a very slightly reduced diameter of the basal part of the barb itself. The degeneration of the barbules has been greater on the inner side next to the shaft, where in many cases the barbules have totally disappeared.

Under the lens, the clean mechanical work of the purely physiological action as compared with the clumsier trimming of the rough beak is plainly visible; the shaft being cleaner and the barbule stumps more regular in the former case.

The physiologically denuded tail feathers reached their full growth within a period of six weeks, and on October 1st, 1909, were in their turn plucked out for examination and reference. The bird had of course by this time completely finished its moult and was in perfect condition.

PART V.

The final stage of this experiment was the observation of the growing tail feathers, succeeding those plucked out October

*Riverside Natural History, Vol. iv, p. 399.

1st. They were slow in starting, but became visible beyond the upper tail-coverts in three weeks and on November 8th had reached a total length of four and one half inches. A compact, unbroken blood sheath surrounded the shaft to within three inches of the tip. Several days previous to this the barbs had been observed to be in disorder as they emerged from the sheath and on one occasion the bird was seen to preen the right feather, pick off a bit of broken sheath and with it several barbs!

On November 8th the denudation had proceeded to a considerable extent and the left feather presented the appearance seen in Fig. 45. The right side of the shaft is comparatively clean while the left side is as yet only partially denuded.

The blood sheath on the right feather was one and three-quarter inches in length and encroached on the area of normal denudation for the last quarter inch. With a pair of pliers I gently pried up the dry end of the sheath and with it came four barbs, leaving two, still affixed to the shaft, so firmly attached that a gentle rubbing did not detach them.

There is not the slightest chance that the bird could have removed this bit of sheath with greater care than did I, so we must conclude that the unusual physiological weakness of the barbs which was so pronounced in the previous pair of feathers that they were perfectly denuded on being freed of the sheath, was continued, but in a less degree in the present set of rectrices. In the succeeding set, perhaps a normal balance will be attained.*

The objection may be raised that this is all a result of abnormal ecological conditions surrounding a captive bird, but it must be remembered that in the several sets of feathers grown before I began my experiments, the feathers attained their full length before being denuded.

Mr. F. M. Chapman has called my attention to two interesting specimens of *Eumomota superciliaris* recently received by the American Museum from Nicaragua. In this species the denudation of the tail-feathers reaches an extreme, the central pair of rectrices extending four and a quarter inches beyond the others, with almost three inches of bare shaft.

In the two specimens mentioned, the central tail-feathers are only partly grown, with only a portion of the denuded area out of the sheath. The web on this portion shows an extreme degeneration, comparable to the normal condition in the tail of

*December 4, 1909. This is confirmed at the present date, when the tail feathers have emerged with unbroken vanes from their sheaths, and the bird thus proved to be in normal condition again.

the parrot *Prioniturus*. The barbs are scanty, but probably are all present when the shaft first emerges from the blood sheath. Each barb breaks off at the proximal end of its line of green pigment. The most noticeable character is the great degeneration in length of these barbs. At the base of the racket the barbs measure one and a quarter inches in length, while barely a half inch farther up the shaft, the barbs are reduced to one-quarter of an inch in length. The dropping off of the barbs is almost contemporaneous with their breaking from the sheath, the shaft being bare long before it has reached its full growth.

Judging from the condition of the rectrices in these two moulting individuals of *Eumomota superciliaris*, the evolution of tail denudation is more advanced in this species than in any of the others I have examined.

A curious asymmetrical condition was observed in a specimen of *Momotus subrufescens* in the collection of the American Museum. The character is apparently individual, as it is not present in other specimens. On holding one of the rectrices, which is intact, up to the light, the longitudinal series of holes which indicate degeneration is observable only along the inner life of the shaft. In the other rectrice the inevitable result of this condition is demonstrated in the asymmetrical denudation, the outer web being entirely absent while the inner web is perfect, and shows no hint of losing even a single barb. This is additional proof that the denudation is wholly dependent on the congenital weakening of the barbs.

PART VI.

My conclusions as to the problem of rectrice denudation in the Motmot are as follows: For some reason, totally unknown to us at present, a certain definite portion of the central rectrices of these birds exhibits congenitally a decided degeneration of the barbs and barbules.

These weakened barbs are usually strong enough to resist the ordinary wear and tear of the feather during its growth. The natural oil or moisture of the feather may not totally evaporate from this terminal portion until growth at the base ceases, although there can be no direct communication between the two points. It is a minor consideration whether the final increase of weakness is due to thorough drying and consequent brittleness or to some other physiological cause.

The Motmot, in the course of the preening to which it subjects all of its rectrices, breaks off the barbs in the area most

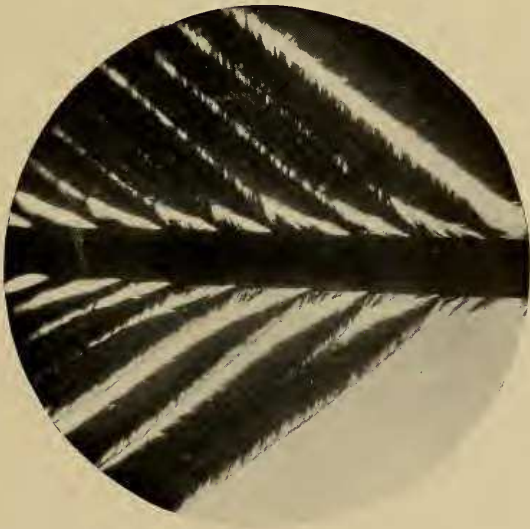


FIG. 46. Showing Congenital Weakness of the Barbs.



FIG. 47. Normal Portion of the Feather.

Photo-micrographs of the Lesson Motmot, magnified 25 diameters.